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Tracking and Control of Acousto-Fluidic Self-Assembly of Microparticles

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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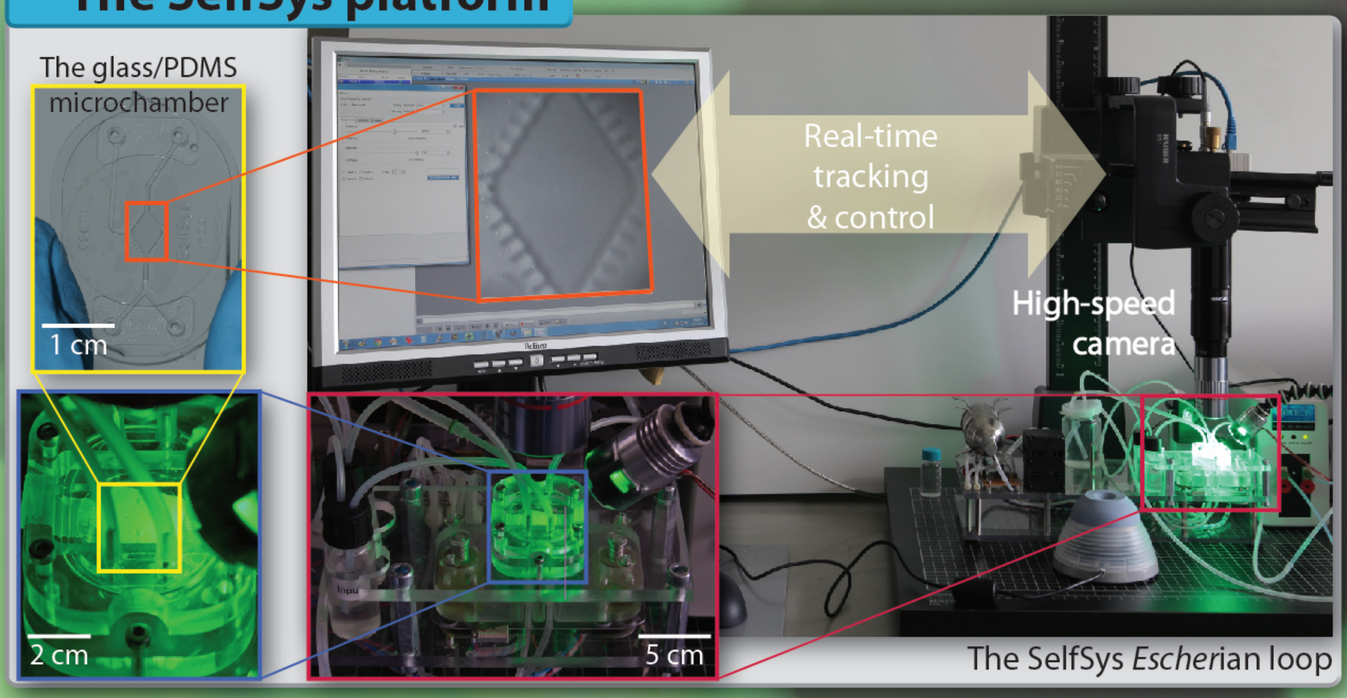
Motivation & Goals

1 **Self-assembly** is a powerful, bottom-up technology for **micro/nanofabrication** and a key **coordination mechanism** for distributed systems of intelligent agents[1].

2 Our research bridges these important domains by investigating self-assembly phenomena **across physical scales and abstraction levels**.

3 We hereby enable and study the self-assembly of microparticles by a **novel fluidic platform**[2], extending the scope of our previous studies at centimetric scale[3] and using the same **multi-level modeling and control framework**[4].

The SelfSys platform



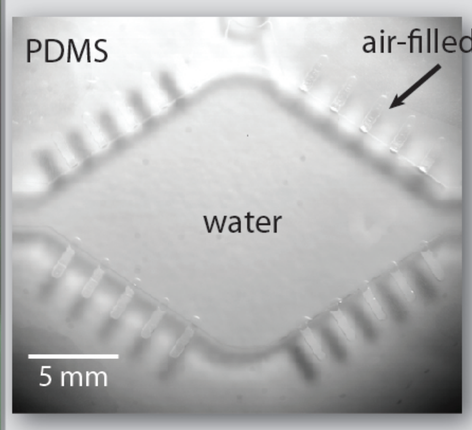
The SelfSys *Escher*ian loop

Actuation and control

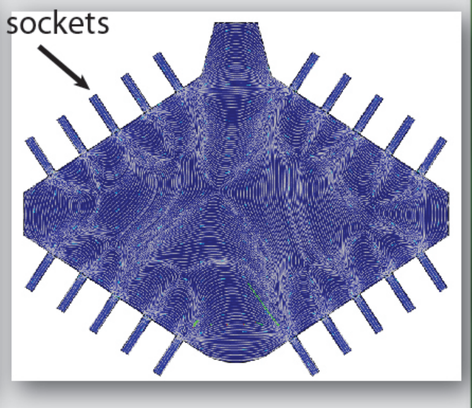
1 The glass/PDMS microchamber is filled with water and air bubbles located in lateral sockets

2 The microchamber is actuated piezoelectrically

3 The acoustic field induces bubbles oscillations and hence microstreaming in the chamber



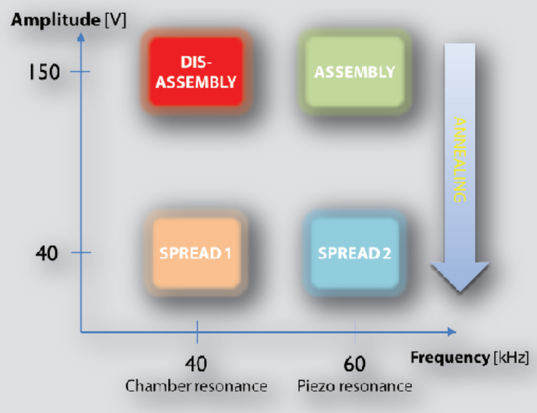
The microchamber with lateral air bubbles

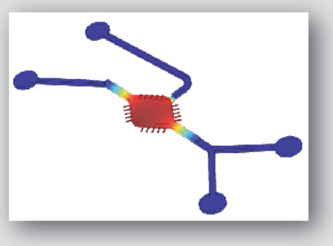


2-phase CFD simulation of acoustic microstreaming

4 The valve-controlled inlets impose the fluid flow to load and unload the microparticles

5 Amplitude and frequency of actuation induce 4 main agitation modes in the microchamber:

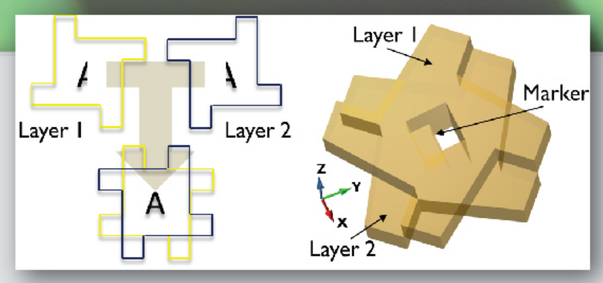




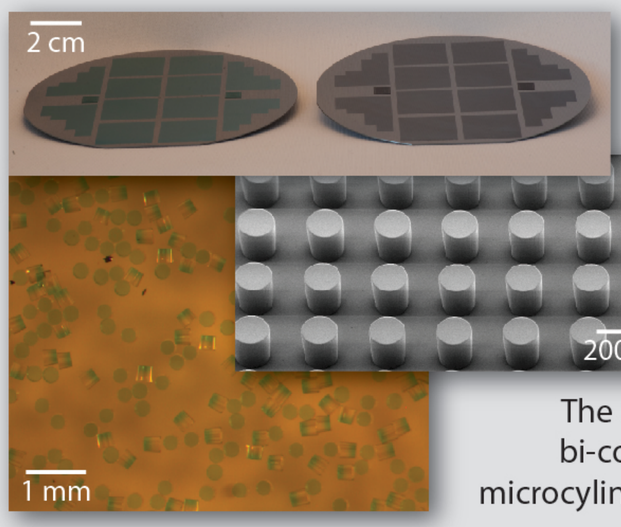
1st mode (42.4 kHz) of the microchamber

Polymeric microparticles

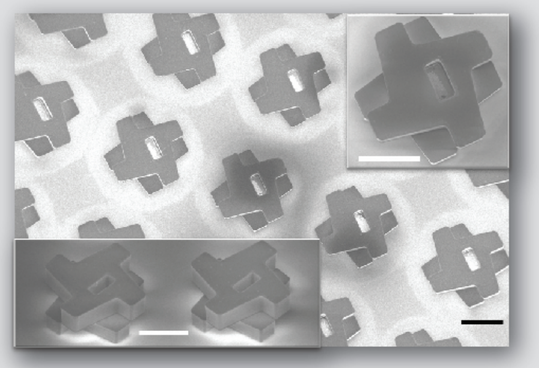
- We designed and fabricated SU-8 microcylinders and 3D microtiles[5] as vehicles for self-assembly studies



Design of the 2-layer SU-8 microtiles



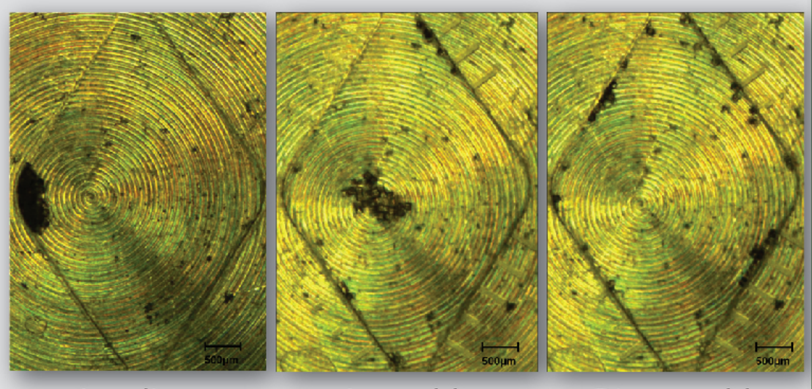
The SU-8 bi-colour microcylinders



SEM of microtiles before release (scale bars = 100 µm)

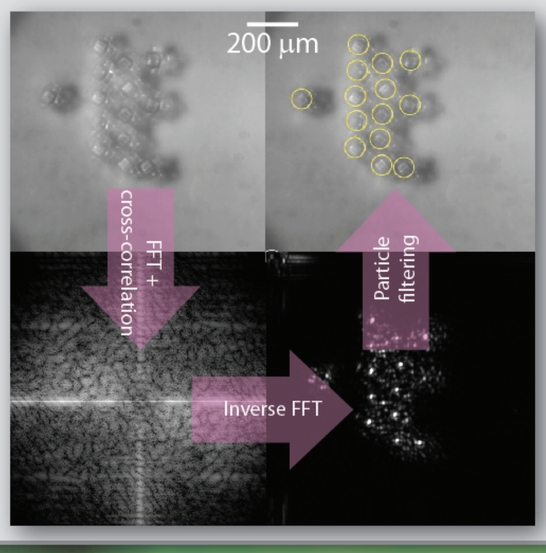
Tracking and control of self-assembly

- High-speed recordings are post-processed by image recognition software to track the trajectories of particles self-assembling in the microchamber



Frames from high-speed video of a self-assembly sequence

Loading Assembly Disassembly



Conclusions & Outlook

1 We developed a novel platform for acousto-fluidic self-assembly

2 High-speed software tracking of assembling microparticles was demonstrated

3 Automatic modeling & control through the M³ framework is being further pursued

Publications

[1] M. Mastrangeli *et al.*, "Modeling Self-Assembly across Scales: the Unifying Perspective of Smart Minimal Particles", *Micromachines* 2 (2011)

[2] J. Goldowsky *et al.*, "Acousto-Fluidic System Assisting In-Liquid Self-Assembly of Microcomponents", *submitted*.

[3] G. Mermoud *et al.*, "Real-Time Automated Modeling and Control of Self-Assembling Systems", *IEEE Int. Conf. on Robotics and Automation 2012*.

[4] G. Mermoud *et al.*, "Automated Modeling of Self-Assembling Robotic Systems: The M³ Framework", *in preparation*.

[5] M. Mastrangeli, J. Brugger, "Three-Dimensional SU-8 Microtiles for Fluidic Self-Assembly", *submitted*.